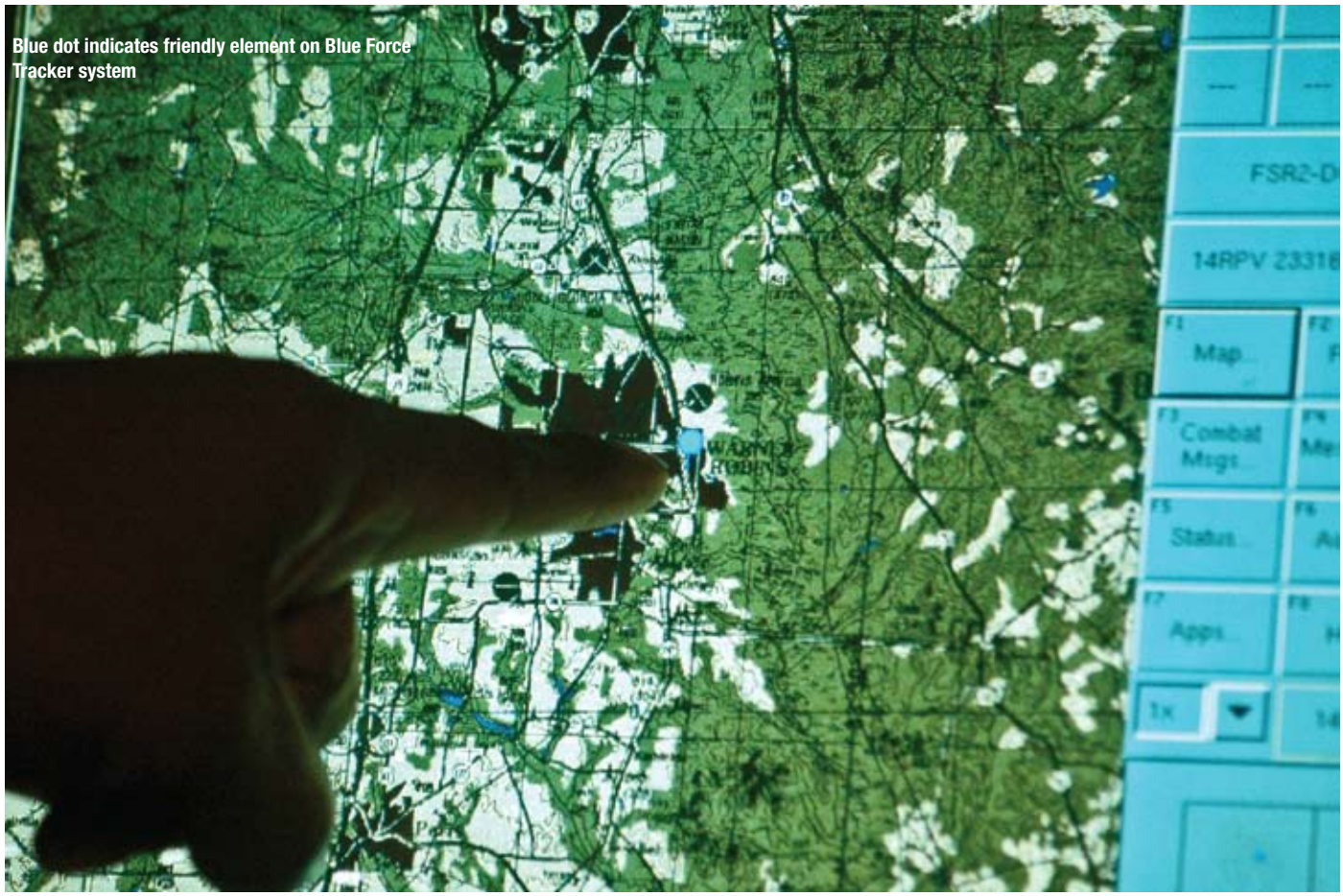

U.S. Air Force (Sue Sapp)

The Global Positioning System
A Case Study in the Challenges of Transformation

By MATTHEW E. SKEEN

U.S. Army

Soldier carries backpack-sized component of early global positioning system, 1981

The Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) is one of very few modern innovations that can legitimately claim the overused title "transformational." Like electricity, GPS technology and GPS-derived information are now ubiquitous. This satellite-based system enables a diverse array of capabilities ranging from online driving directions to computer networking to political gerrymandering.

GPS technology is equally pervasive within the military, where it creates efficiencies and enhances tactics, techniques, and procedures (TTPs) in every warfighting domain. Indeed, the merits of GPS seem obvious, but they were not so clear at many key decision points in the program. In fact, the 48-year history of satellite navigation provides an excellent case study in the challenges associated with Department of Defense (DOD) transformation.

This essay focuses on four specific periods in GPS history that provide clear lessons for those individuals leading transformation. In the first two periods, the contrast between the strong leadership that spurred the decision to formally start the GPS program and the lackluster leadership that later encouraged a congressional committee to recommend terminating it demonstrates the essential importance of visionary leadership in the higher levels of DOD. Next, an examination of an operational success and a missed opportunity in Operation *Desert Storm* highlights the benefit of

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harnessing the creativity of our Soldiers, Sailors, Marines, and Airmen in the field to accelerate transformation. Finally, a brief consideration of GPS today provides a clear reminder that effective transformation does not shift our forces from one technology to another, but rather creates an organization that is able to stay ahead of adversaries who use the tools of our globalized world to counter our strengths.

1973 DSARC

In December 1973, the GPS program passed through its first major obstacle when the Defense Systems Acquisition Review Council (DSARC) approved entry into Phase I of development.[1] This decision was forged from competing organizational interests both in the Services and the Office of the Secretary of Defense (OSD). The decision was also affected by other elements of the domestic context including the preferences of engineers, precedents set by research programs, process changes driven by the war in Vietnam, and a chance meeting between a new political appointee and an Air Force colonel. In the end, strong leadership was essential to overcoming the inertia imposed by competing forces.

The Navy became the first Service to stake a claim in the satellite navigation business in the earliest days of the space age. When the Russians launched Sputnik in 1957, researchers at The Johns Hopkins University Applied Physics Laboratory began tracking the satellite by measuring its radio broadcasts.[2] These researchers then proposed that the Navy reverse this process to use satellite broadcasts to help submarines locate themselves.[3] On April 13, 1960, less than 3 years after the Sputnik launch, the Navy launched the first Transit navigation satellite to test this theory.[4] In 1964, the Naval Research Laboratory conceived another satellite navigation concept based on highly accurate clocks.[5] This concept developed into the Timation program that launched its first satellite in 1967. These successful programs set the precedent for the Navy to operate satellite navigation systems. They also reinforced the Service's natural preferences to avoid relying on other Services and to field systems optimized to meet Navy-specific needs. Furthermore, the researchers who devoted years to perfecting the systems developed strong personal preferences for their concepts.

In parallel with the Navy, the Air Force and Army joined the game with different satellite navigation concepts. The Air Force initiated Project 621B in 1963 to evolve a concept based on a pseudorandom noise signal.[6] This concept was tested using balloons to simulate satellites.[7] The Army operated 16 sequential-correlation-of-range satellites between 1964 and 1970 using its own technical concept.[8] Similar to the Navy programs, these programs set the precedents for Service-specific systems and fostered each player's preference for its own technological concept.

The Services may have continued their separate programs if not for the advent of a fourth major player with the power to force a change: the Director of Defense Research and Engineering (DDR&E), Malcolm Currie.[9] The DDR&E chaired the DSARC, which had been established by OSD in 1969 as congressional dissatisfaction with the war in Vietnam began increasing the pressure to reduce defense spending.[10] In April 1973, the Deputy Secretary of Defense directed the Services to form a joint program office, led by the Air Force, to develop a single navigation satellite system meeting all three sets of Service requirements.[11] As head of the DSARC, Dr. Currie was the ultimate approval authority for the acquisition plan. While the Services participated in the DSARC and could effectively veto a plan that did not meet their needs, only Currie had approval power. His objective was to meet the Services' needs while avoiding costly duplication of effort.

the Services may have continued their separate programs if not for the advent of the Director of Defense Research and Engineering

The Air Force's first attempt to establish a joint program failed; the Service attempted to substitute its own program for the joint program. After receiving direction to form a joint program office, the Air Force converted its Project 621B Program Office into the new Defense Navigation Satellite System Program Office under the command of Colonel Brad Parkinson.[12] In August 1973, the DSARC met and disapproved Parkinson's proposed plan for the joint program because it was essentially a repackaged version of Air Force Project 621B.[13] The Army and Navy representatives at the DSARC blocked the plan. After the meeting, Currie met with Parkinson and told him, "Brad, don't worry about it. You can get this right. What I want you to do is go back and make your program a joint program."[14]

Currie's solid support for satellite navigation may have resulted from a chance meeting with Parkinson a few months earlier. The two met soon after Currie was appointed to his position as DDR&E in the second term of the Nixon administration. Currie was traveling regularly between Washington, DC, and Los Angeles, visiting the Air Force Space and Missile Systems Organization in El Segundo, California. On one visit, Parkinson spent 4 hours explaining the need for a satellite navigation program and his plan to create it. Parkinson's argument must have been persuasive because Currie "exited with a view that he wanted to do this,"[15] attesting to the important role that individuals have in transformation.

After failing to gain approval in his first attempt, Parkinson developed a new proposal including the best features of each of the Service programs. He held a meeting at the Pentagon over Labor Day weekend to synthesize a new program, which incorporated Transit's orbit determination, Timation's precise clocks, and a revised version of the Air Force pseudorandom noise signal.[16] This program even included a plan to use the Army's Yuma Proving Ground as one of the primary test sites.[17] Essentially, this program laid out GPS as it exists today.

The plan was approved by the DSARC in December 1973 because it mitigated the concerns that led the Services to veto the previous plan. The Services were convinced that at least some elements of their original programs were incorporated into the new system. The personal interests of the individual Service researchers were addressed in the Labor Day meeting, where the best elements of each system were synthesized. This synthesis also addressed the Services' preferences for technology optimized to meet their individual needs. Finally, the DDR&E was able to comply with his mandate to eliminate duplication of effort while fielding a system he felt would provide significant benefit.

This study demonstrates some major bureaucratic challenges that continue to make transformation difficult today. There were communities within each Service that saw the potential for satellite navigation to transform their operations, but the Navy and Air Force each wanted to control the program. This sort of tension is natural for three reasons. First, each Service wanted to optimize the system for

its own mission set. Second, each Service had already invested time and money to develop a solution. Finally, neither Service wanted to depend on an outside organization to provide a mission-essential service. DOD was facing declining budgets and had established the DSARC process to work through disputes such as this, but the process was not going to enable transformation. In fact, the failure of the August 1973 DSARC proves that bureaucratic players can use such processes to slow it. In examining these challenges, it is easy to find parallels between the early GPS debate and today's discussions about unmanned aircraft systems or cyberspace operations. In 1973, leadership was the key to overcoming these challenges.

Currie and Parkinson provided the leadership required to maneuver the GPS program around the bureaucratic roadblocks. They had not only the vision to see the value of GPS, but also the ability to see their own biases and the courage to make decisions in the face of opposition. Parkinson envisioned the transformational benefits of precision satellite navigation and seized an unexpected opportunity to share that vision with Currie, who recognized the potential value of the mission. But Currie did not attempt to force the Air Force concept on the other Services. He knew that each Service had valid reasons for advocating its concept and that each Service's needs had to be addressed in the final solution. At the August DSARC, Currie directed Parkinson to create a truly joint program to achieve that final solution. Currie's visionary leadership accounted for both the technical issues and the bureaucratic issues inherent in any decision of this magnitude. Without Currie's hands-on leadership, the bureaucratic processes could have sustained the disputes between the Services for years. Almost a decade later, the debate over the annual defense authorization would make evident the negative impact when visionary leadership falters and the bureaucratic processes begin to dominate the discussion.

FY82 Defense Authorization

In contrast to the visionary leadership guiding the 1973 DSARC, the lead-up to the fiscal year (FY) 1982 Defense Authorization demonstrates the potential consequences of lackluster leadership. After reviewing the President's proposed budget, the Senate Armed Services Committee (SASC) funded the GPS program, but the House Armed Services Committee (HASC) recommended terminating it. Like the 1973 DSARC decision, this decision was affected by the domestic context. In particular, the Air Staff's weak support for the program created opportunities for General Accounting Office (GAO) analysts both to frame the debate in terms they preferred and later to exploit an unexpected change in HASC membership to target the program. During this period, the GPS transformation faltered because the GAO framed the issue narrowly in terms of costs and benefits associated with replacing several existing navigation systems with a slightly more accurate one. The GAO did not assess the benefits of visionary new applications like GPS-guided munitions, GPS-enabled survival radios, or the computerized GPS navigators in many cars today.

The GPS program had made significant progress between the 1973 DSARC decision and the FY82 budget debate in the fall of 1981, but the program also experienced problems. Six prototype satellites had been launched and preliminary test results exceeded the technical performance requirements. However, the program was running over budget and falling behind schedule. The forecasted initial operational capability date slipped from 1984 to 1986, and the cost of the work between the 1973 DSARC and the next DSARC in 1979 ballooned beyond the original estimate of $178 million to over $400 million.[18] In spite of the cost and schedule problems, the 1979 DSARC approved the start of full-scale development.

Currie and Parkinson had not only the vision to see the value of GPS, but also the ability to see their own biases and make decisions in the face of opposition

During this same period, the Air Force weakened the program by failing to provide adequate funding. As defense budgets declined in the late 1970s, the Air Force repeatedly tried to cut GPS funding.[19] There were two likely motivations for these cuts. On one hand, it is possible the Air Staff could not envision the true potential of the GPS transformation. Like the GAO analysts, the Air Staff may have seen GPS as just a replacement for existing navigation systems and judged that other initiatives would provide more bang for the buck. On the other hand, the Air Staff may have understood that there would be significant benefits across all the Services, but believed the Air Force was being forced to pay more than its fair share of the cost. In this case, cutting the funding was a ploy to get OSD to increase the Air Force budget to fund the difference. Neither of these perspectives provides an example of the visionary leadership needed for successful transformation because the proposed cuts weakened congressional support for the program. Prior to the FY82 budget debate, the GAO further weakened HASC support for GPS by publishing three skeptical assessments of the program.

The first report was issued in 1977 and criticized the GPS program for failing to follow established procedures. The major findings centered on the fact that the user community had not formally established its need for a new capability and set the acceptable cost and schedule limits for fielding that capability before the GPS program was initiated at the 1973 DSARC.[20] The report also indicated the DSARC had selected a satellite-based solution for its navigation needs without first studying alternative ways to meet those needs.[21] This report essentially staked out the positions that there might not be a valid need for improved navigation capability, and, if there was a need, GPS might not be the most cost-effective way to meet it. In the minds of the GAO analysts, this failure seriously called into question the decision to build the system.

The second report criticized the cost and schedule performance of the program and restated concern about the benefit of the system relative to cost. The report noted that "much uncertainty currently exists concerning who the individual users will be and what their specific needs are."[22] The report went on to state, "We are concerned that unless the uncertainties pertaining to improved force effectiveness and potential cost savings are resolved, the soundness of the pending [DSARC] decision to proceed with GPS development could be jeopardized."[23] It further noted that the Under Secretary of Defense for Research and Engineering (formerly known as the DDR&E) had testified to the Senate Commerce, Science, and Transportation Subcommittee that GPS could save the Nation $200 million per year, but that DOD was unable to provide documents as evidence for this testimony.[24] This report's concern that GAO was unable to verify the DOD claim that there would be 27,000 military users reflects the previous report's concern about the failure to follow established procedures. This concern is obvious in the statement that "this inability to track individual users reflects the origin of the program; i.e., unmet needs and identified deficiencies of specific individual users were

not the driving force behind the program being initiated."[25] In short, this second report clearly framed the debate in terms of identifying existing users who would switch to GPS navigation and the mission benefit increased navigation accuracy would provide to those users. There was no attempt to assess the benefits of transformational new applications of the system.

The third GAO report focused more on the benefits of the system relative to its costs. The GAO and DOD finally agreed on a projected cost of $8.6 billion through the year 2000.[26] The two organizations also agreed that there would be at least 14,000 users by 2000 and that the system would provide improved military effectiveness.[27] For example, DOD studies calculated that 1,465 GPS-equipped aircraft could destroy the same number of fixed targets as 1,714 aircraft without GPS. They then calculated that the cost of the additional 249 aircraft would exceed $7 billion. If the system cost $8.6 billion and achieved $7 billion in benefit in this scenario and more benefit in other scenarios, it might be a good investment. From today's perspective, this was a narrow assessment of the benefit of GPS.

Without visionary leadership, the bureaucratic process will default to conservative positions. In this case, the fact that DOD did not follow the procedure of documenting the unmet need before the program was established raised a red flag for the GAO. This failure may have resulted from Currie's personal support for the program—he shared the program office's transformational vision. However, this challenge is likely to be faced by any transformational program because users may lack the vision to see the potential benefits. GAO concerns about this process deviation were amplified by the fact that the program failed to provide hard data on the number of users. Future transformational programs are also likely to face this problem because users are simply reluctant to commit to adopting a revolutionary new technology before it is proven. In this period of GPS history, conservative bureaucratic processes were able to frame the debate narrowly because the Air Staff failed to provide visionary leadership for the program. The GAO's critical assessments would not have impacted the program if the membership of the HASC had not changed unexpectedly.

The domestic political environment following the 1980 elections set the stage for the HASC to recommend terminating the program. The key change was Representative Charles Wilson's (D–CA) departure from the committee.[28] Wilson represented California's 31st district in the suburbs of Los Angeles, had been a member of Congress since 1962, and was a senior member of the HASC majority. The 31st district was solidly Democratic, and Wilson would likely have been reelected had he not drawn attention to himself. However, he lost the Democratic primary in 1980 after being censured by the House for lying about a cash gift he received from Tongsun Park, who was working for the South Korean central intelligence agency.[29] The economy of Wilson's district was heavily reliant on the defense plants around it, including Rockwell International's Seal Beach GPS factory. If Wilson had still been a member of the committee, GAO concerns about GPS would have fallen on deaf ears.

Without Representative Wilson championing GPS, power shifted to committee staffers who were influenced by the GAO assessments. Citing many of the issues raised in the GAO reports and concerns about the "large out-year mortgages" developing in DOD programs, the HASC report recommended terminating GPS, stating, "The price tag is far too high for the additional capability it would ultimately provide."[30] However, the program was not terminated because the SASC remained supportive during this first year of the Reagan defense buildup. The defense authorization that was finally signed into law removed $100 million of the President's requested $400 million, but it more closely matched the SASC support for the system than the HASC skepticism.[31]

The events surrounding the FY82 Defense Authorization show that without visionary leadership at high levels within the Services and OSD, transformation may fail as competing priorities draw away needed resources. This study also affirms the element of chance that people bring to the decision-making process. Just as the chance meeting between Parkinson and Currie affected the 1973 DSARC decision, the unexpected departure of a solid political backer affected HASC support.

The Gulf War

Operation *Desert Storm* is often described as the "first space war" in large part because of the role GPS played in the conflict. In a comprehensive after-action report on the war to Congress, DOD consistently praised the benefits of GPS and recommended that it be considered for incorporation in all weapons systems and platforms.[32] One reason for the

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Marines patrolling in Anbar Province check global positioning system

U.S. Marine Corps, Regimental Combat Team 5 (William Skelton)

success of GPS was the ability of American troops to quickly develop tactics to exploit this emerging technology. A brief examination of one operational success and a missed opportunity for GPS in this conflict highlights the benefit of harnessing the creativity of troops in the field to accelerate transformation and suggests that we should actively seek opportunities to take advantage of this creativity as early as possible when fielding a new system.

Operation *Desert Storm* took place just as the Air Force was fielding the first fully operational GPS satellite constellation. In the 16 months prior to the conflict, the Service launched 8 of the planned 24 Block II satellites, with the eighth one lifting off from Cape Canaveral on the day that Saddam Hussein invaded Kuwait in August 1990.[33] The Air Force was able to launch two more satellites before the start of the air campaign in January 1991.[34] In conjunction with several Block I prototype satellites that were functioning beyond their design life, these satellites provided two-dimensional (latitude and longitude) coverage of the theater for almost 24 hours per day and three-dimensional (latitude, longitude, and altitude) coverage for about 19 hours per day.[35]

In the first minutes of the air campaign, the operational success of Task Force Normandy provided an excellent example of the creativity of our joint warfighters. This task force was a group of Army AH–64 attack helicopters guided by Air Force MH–53 special operations helicopters that penetrated Iraqi air defenses at low level at night to destroy two early warning radars.[36] This mission helped breach the Iraqi air defenses and allow waves of aircraft to begin making attacks deeper inside the country. The Airmen and Soldiers planning the air campaign developed this tactic when they realized the MH–53s did not have the firepower to destroy the targets and the AH–64s did not have the navigation accuracy to find the targets at night in the featureless desert. (It is interesting that this is just one of many innovations the GAO analysts did not foresee in their reports assessing the cost and benefit of GPS 10 years earlier.) Official accounts of Operation *Desert Storm* are uniform in their praise for GPS because the list of operational successes similar to Task Force Normandy's mission is so long. However, many of the GPS-enabled TTPs employed in *Desert Storm* were developed at the last minute because few troops had even heard of GPS prior to the conflict.[37]

A few missed opportunities emerge when the shortcomings of Operation *Desert Storm* are considered in light of the opportunities to avoid them. A significant example involves fratricide. Official reports of *Desert Storm* note that GPS prevented friendly fire casualties because improved navigation accuracy reduced the number of times coalition units accidentally came into contact with each other.[38] When coalition forces attacked during Operation *Iraqi Freedom* a decade later, the likelihood of fratricide was decreased even further by a GPS-based technological solution known as Blue Force Tracking.[39] However, it is possible that joint forces may have developed better GPS-enabled procedures to decrease the incidence of fratricide in *Desert Storm* if operational units had the opportunity to use GPS in joint exercises in the years prior to the war.

U.S. Navy (Xander Gamble)

USS *Oklahoma City* embarks using Voyage Management System

one reason for the success of GPS was the ability of American troops to quickly develop tactics to exploit this emerging technology

The potential to develop better procedures to avoid fratricide is an example of a missed opportunity to accelerate the pace of transformation by conducting more joint exercises earlier in the development phase. Opportunities to work with GPS prior to Operation *Desert Storm* were limited because full fielding of the receivers was synchronized with the projected full operational capability of the Block II GPS constellation that was still a few years away when *Desert Storm* started.[40] In fact, when Iraq invaded Kuwait, the U.S. Army only owned 500 demonstration receivers.[41] However, the Block I satellites had been adequate to support joint exercises and testing for almost 10 years prior to Saddam's invasion of Kuwait. To mitigate user equipment shortages, these exercises could have used commercially available civilian GPS receivers that performed the same navigation functions as military receivers but lacked the ability to use the military-only encrypted signals. Thousands of these same commercial receivers were purchased by DOD in the months prior to Operation *Desert Shield*, where 85 percent of the 5,300 GPS receivers employed were commercial.[42] DOD missed an opportunity to accelerate the GPS transformation and shorten the overall timeline for integrating GPS into the force by developing more tactics in parallel with the equipment. The best way to accelerate transformation is to get representative equipment into the hands of the troops so they can use it to solve the problems they are facing in the field.

The concept of spiral development is another way to accelerate transformation. The basic concept is to field new systems in increments of increasing capability. In other words, the first version of a system may be much less capable than the final version, but it is fielded much earlier. While spiral development may increase the time required to field the most highly prized features, it has the potential to accelerate the pace of transformation because it harnesses the greatest strength of DOD—the expertise and creativity of personnel in the field. Hundreds or even thousands of troops using a new system will develop innovative TTPs to exploit strengths in ways that were not anticipated by its relatively small group of developers. Taken together, the advantages of fielding these transformational TTPs sooner may even outweigh the anticipated benefit of the features in the next version of the system.

GPS Today

The recent history of GPS serves as a clear reminder that transformation involves much more than a series of shifts from one technology to another. In the years since

Operation *Desert Storm*, the GPS satellite constellation has reached full operational capability, and GPS-enabled systems have become ubiquitous in both combat and support roles. Most experts would agree that GPS enabled transformation within the American military. However, this does not mean that DOD has achieved GPS transformation and can now move on to transforming some other segment of the joint force. In war, it is inherent that adversaries will react to our advances and strive to counter them. Saddam's attempts to employ GPS jammers in Operation *Iraqi Freedom* and terrorist use of GPS to survey targets provide two obvious examples of adversary attempts to counter our GPS advantage.

An interconnected and globalized world helps potential adversaries ranging in scale from nation-states to terrorist groups to gather and share information about our strengths and weaknesses and to develop tactics and equipment to exploit those weaknesses. The fact that adversaries are working to counter our GPS advantages affirms that the essence of DOD transformation is to create an organization that is able to stay ahead of adversaries who quickly use the tools of the globalized world to counter our strengths. That organization must be manned with visionary leaders working to harness the unbounded creativity and individual leadership of our Soldiers, Sailors, Marines, and Airmen.

The American military's greatest strength is exceptional leadership. This brief examination of four periods in the history of the Global Positioning System shows that the best way to enable transformation is to put it into the hands of leaders at every level. The early history of the system demonstrates that top leaders must have the vision to assess new concepts, which have the potential to improve the full spectrum of joint operations. If this assertion is true, then we must seek ways to develop this vision through training and experience targeted at preparing leaders to make these decisions. These same leaders must be empowered to use bureaucratic processes as decisionmaking aids with the understanding that these processes tend to be conservative and thus slow the pace of change. Operation *Desert Storm* clearly shows how well our troops in the field lead transformation when they are empowered to use their creativity and unique mission knowledge to develop TTPs exploiting the full potential of new technology. Joint exercises and spiral development are two potential methods of harnessing this creativity earlier in the transformation process. Finally, recent GPS history reminds us that the real challenge of transformation is to create an agile, adaptable organization, because potential adversaries are constantly reacting to our own developments and may even find ways to use them against us.

This case study also calls attention to the fact that while the world outside the Department of Defense is changing rapidly, many of the internal organizational challenges we face in transforming the department are similar to those faced at other times in history. These challenges are inherent to leading any large organization. As we work to adapt our organization and its processes to the 21st century, it may be useful to examine more of these transformational cases to enrich our understanding of past successes and failures. Other useful case studies might include the Navy's development of nuclear-powered submarines, the Army's development of the National Training Center at Fort Irwin, the Air Force development of stealth and precision-guided munitions, or the joint implementation of the Goldwater-Nichols Act. **JFQ**

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